Biochemical Turing Machines “Reboot” the Watchmaker Argument

May 1, 2012

By Dr. Fazale Rana



Who’s the father of computer science? Although not a household name, [Alan Turing](http://en.wikipedia.org/wiki/Alan_Turing) (1912–1954) and his work have impacted nearly every facet of human existence. When he was 24 years of age, the British mathematician developed the theoretical framework that makes digital computing possible. This framework is embodied by an abstract, conceptual machine called a [Turing machine](http://en.wikipedia.org/wiki/Turing_machine).

In reality, Turing’s influence extends far beyond computer science. He founded the field of artificial intelligence, speculated on the limits of computation in physics, and wrote about biological pattern formation that occurs during development. He even played the key role in deciphering the German Enigma Code (secret messages) during World War II.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Turing Machines**

At a fundamental level, all computer operations are based on so-called Turing machines. Named for British mathematician Alan Turing, the machines are not real, but conceptual in nature. Turing machines consist of three components: the input, the output, and the finite control.

The input is a stream of data that is read and transformed by the finite control according to a specific set of rules. The result of this transformation is a new stream of data, the output. The input and output data streams consist of sequences of characters called strings. The finite control operates one by one on each character of the input string to generate the output string. The transformations achieved by the finite control are relatively simple in nature. Complex computations and operations can be affected by linking together several Turing machines, so that the output string of one Turing machine becomes the input string of another.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Turing’s work also carries significance for the creation/evolution controversy, as attested by a provocative article in *Nature*.1 Due to Turing’s importance (and relative obscurity), *Nature* celebrated the 100th anniversary of his birth in their [February 23, 2012](http://www.nature.com/news/specials/turing/index.html) issue. A number of scholars, including Nobel Laureate [Sydney Brenner](http://en.wikipedia.org/wiki/Sydney_Brenner) contributed essays describing Turing’s influence in their discipline.

**Turing Machines in Biology**

Brenner, who made significant contributions to molecular biology, proposes that the concept of a Turing machine may provide the theoretical framework that contemporary biology needs to understand life’s operation at its most basic level. According to Brenner, “Biology research is in a crisis and in Alan Turing’s work there is much to guide us. Technology gives us the tools to analyze organisms at all scales, but we are drowning in a sea of data and thirsting for some theoretical framework with which to understand it.”2

He goes on to write, “Arguably, the best examples of Turing’s…machines are to be found in biology…The concept of the gene as a symbolic representation of the organism—a code script—is a fundamental feature of the living world and must form the kernel of biological theory.”3

In other words, in order to develop a (badly needed) theory of biology, it is necessary to view biochemical and biological systems as Turing machines.

**Turing Machines and DNA Computing**

Brenner is not the first scientist to appreciate the close similarity between the abstract, conceptual machines envisaged by Turing—machines that define the operation of digital computers—and biochemical systems.  
Computer scientist [Leonard Adleman](http://www.usc.edu/dept/molecular-science/fm-adleman.htm) recognized more than a decade ago that the [proteins](http://en.wikipedia.org/wiki/Proteins) responsible for [DNA replication](http://en.wikipedia.org/wiki/DNA), [repair](http://en.wikipedia.org/wiki/DNA_repair), and [transcription](http://en.wikipedia.org/wiki/Transcription_(genetics)) operated as Turing machines.4 This insight inspired the advent of [DNA computing](http://en.wikipedia.org/wiki/DNA_computing), a new arena of biotechnology.

DNA computing treats the [nucleotide](http://en.wikipedia.org/wiki/Nucleotide) sequences of DNA as input and output strings. The different chemical, biochemical, and physical processes that can be used to manipulate DNA in the laboratory correspond to the finite control that then transforms the input DNA sequences into output sequences.5 Complex operations can be accomplished by linking together simple laboratory operations performed on DNA with the output of one laboratory operation serving as the input for the next.

Some of the operations that can be executed on DNA “strings” include: separating and fusing strands of the DNA double helix; lengthening and shortening individual DNA strands; cutting and linking together DNA molecules; and modifying, multiplying, and reading the DNA nucleotide sequence.6 Linking these simple operations together makes complex operations possible.

Researchers recognize several advantages to DNA computers.7 One is the ability to perform a massive number of operations at the same time (in parallel) as opposed to one at a time (serially) as demanded by silicon-based computers. Secondly, DNA has the capacity to store an enormous quantity of information. One gram of DNA can house as much information as nearly 1 trillion CDs. And a third benefit is that DNA computing operates near the theoretical capacity with regard to energy efficiency.

It’s mind-boggling to think that the information-based activities of biochemical systems, which routinely take place in the cell, can be used to construct computers in a laboratory setting. The direct correspondence between input and output strings and DNA sequences makes two things clear: (1) DNA is, at its essence, information and (2) the cell’s machinery that manipulates DNA consists of an ensemble of Turing machines. Molecular-level computers have long been the dream of nanotechnologists. By making use of the cell’s information systems to build DNA computers, this dream may become a reality.

**Turing Machines and the Watchmaker Analogy**

DNA computing and the biochemical Turing machines found inside the cell exhibit a very powerful Watchmaker-type argument for God’s existence.

British natural theologian [William Paley](http://en.wikipedia.org/wiki/William_Paley) (1743–1805) advanced this argument by suggesting that the characteristics of a watch and the complex interaction of its precision parts for the purpose of telling time implied the work of an intelligent designer. Paley asserted by analogy that just as a watch requires a watchmaker, so too, life requires a Creator, since organisms display a wide range of features characterized by the precise interplay of complex parts for specific purposes.

Over the centuries, skeptics have maligned this argument. But the discovery of molecular motors––biochemical complexes with machine-like characteristics––[revives Paley’s argument](http://www.reasons.org/facts-faith/issue02). The mounting recognition that the biochemical machines that operate on DNA are veritable Turing machines adds a compelling component to the revitalized Watchmaker argument.

Turing machines are conceptual machines that exist only in human minds, yet inside the cell several actual Turing machines operate on DNA. This recognition presents a powerful double analogy for intelligent design. Not only do biochemical Turing machines highlight the informational aspects of DNA, but also they serve as a remarkably profound Watchmaker-type of analogy. However, in this instance, the analogy is between the *concrete* biochemical Turing machines already present inside the cell and the *conceptual* Turing machines that have come to exist in the human mind.

The wonder and impact of Alan Turing’s life and work are far-reaching, indeed.

Subjects: Biochemical Design

Dr. Fazale Rana

In 1999, I left my position in R&D at a Fortune 500 company to join Reasons to Believe because I felt the most important thing I could do as a scientist is to communicate to skeptics and believers alike the powerful scientific evidence—evidence that is being uncovered day after day—for God’s existence and the reliability of Scripture. [Read more about Dr. Fazale Rana](http://www.reasons.org/about/who-we-are/fazale-rana)



ENDNOTES:

1. Sydney Brenner, “Life’s Code Script,” *Nature* 482 (2012): 461.

2. Brenner, 461.

3. Ibid.

4. Leonard M. Adleman, “Computing with DNA,” *Scientific American*, August 1998, 54–61.

5. Ibid.

6. Gheorghe Pӑun, Grzegorz Rozenberg, and Arto Salomaa, *DNA Computing: New Computing Paradigms* (Berlin, Germany: Springer-Verlag Berlin Heidelberg, 1998), 19–41.

7. Pӑun et al., 1–6; Leonard M. Adleman, 54–61.